

# Data Assimilation of SMAP Observations and the Impact on Weather Forecasts and Heat Stress

**Bradley Zavodsky (NASA/MSFC)**

Jonathan Case (ENSCO, Inc.)

Clay Blankenship (USRA)

William Crosson (USRA)

Kristopher White (NOAA/NWS)

SMAP Applications Focus Session on Health and Disease Exposure

7-8 January 2014



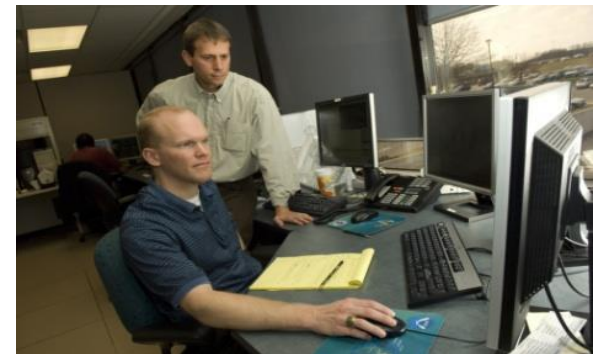
# Short-term Prediction Research and Transition (SPoRT)

**Mission:** Transition unique NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on a regional and local scale.

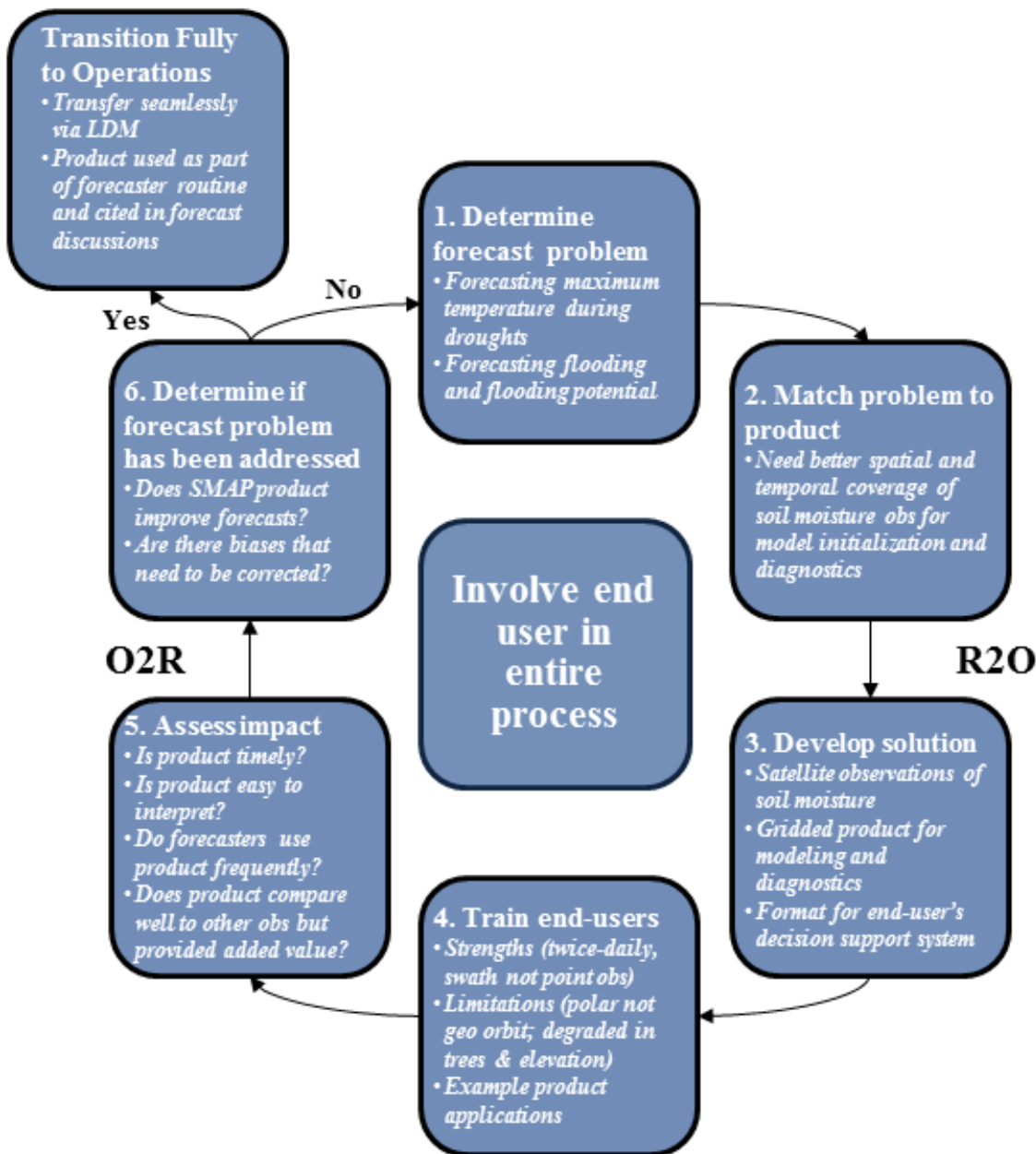
- Close collaboration with numerous WFOs and National Centers across the country
- SPoRT activities began in 2002, first products to AWIPS in 2003
- Co-funded by NOAA since 2009 through “proving ground” activities
- Proven paradigm for transition of research and experimental data to “operations”

## **Benefit:**

- Demonstrate capability of NASA and NOAA experimental products to weather applications and societal benefit
- Take satellite instruments with climate missions and apply data to solve shorter-term weather problems



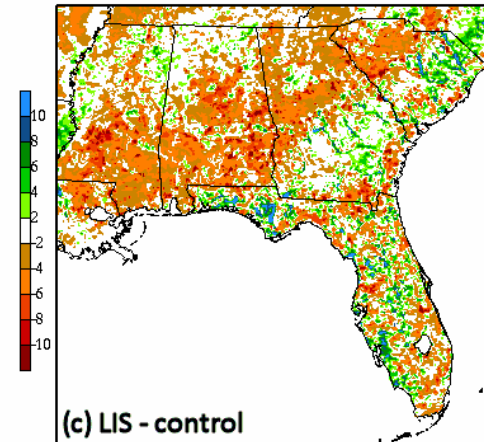
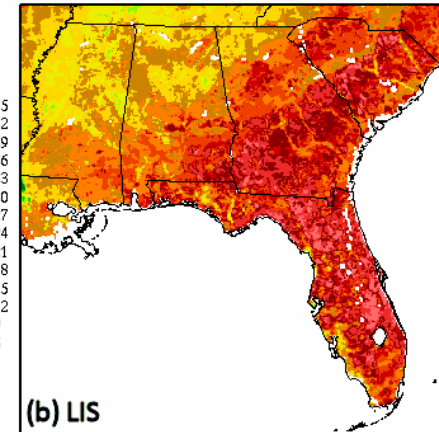
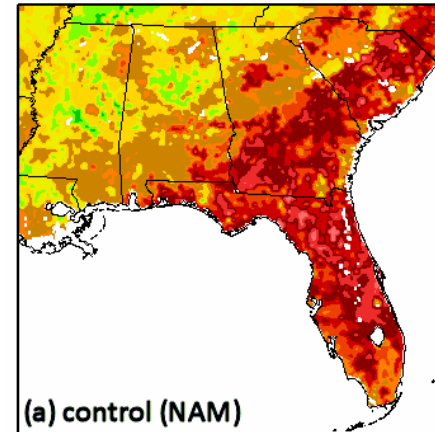
# SPoRT R2O/O2R Paradigm

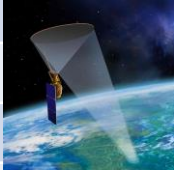


- Match forecast challenge to data/product
- Develop solution/ demonstrate in "test bed" environment
- Integrate successful products into end user's decision support system
- Create product training
- Perform targeted product assessments
- Maintain interactive partnership with end user throughout process
- Need local end user advocate

# Motivation for Using SMAP Data

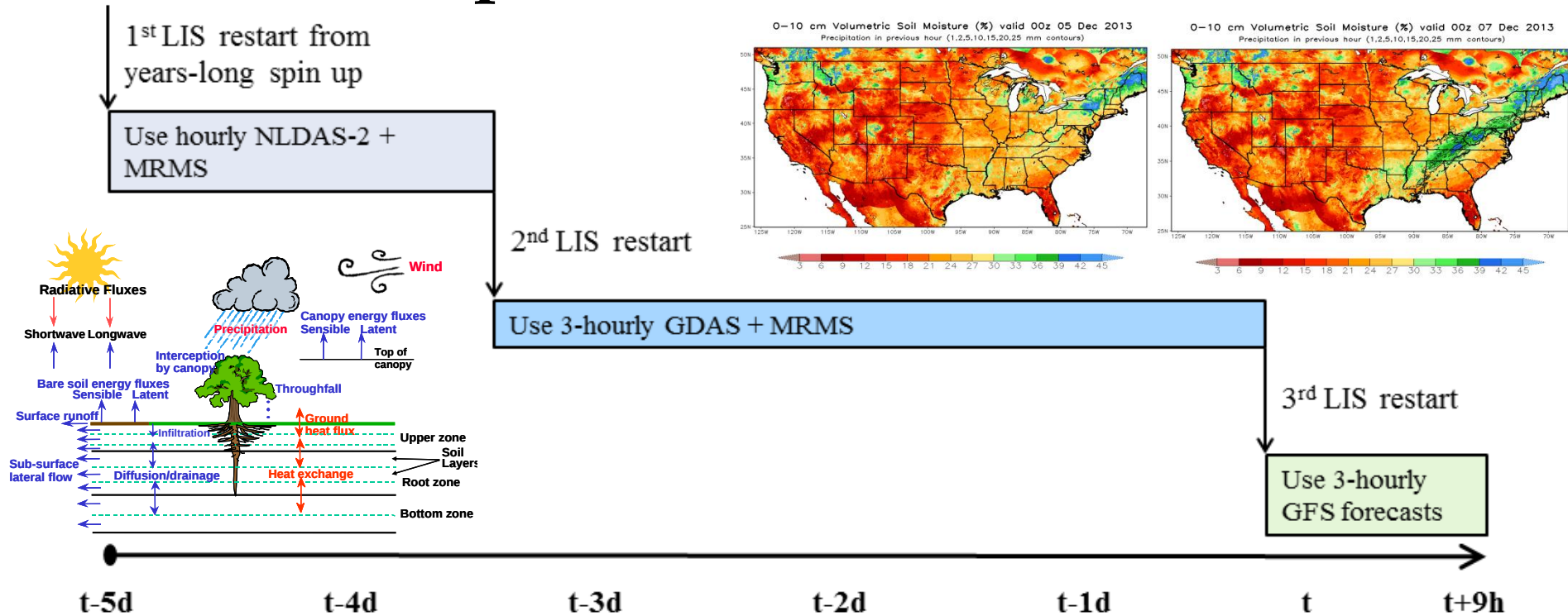
- Proper characterization of real-time ( $< 3$  h), local-scale ( $< 10$  km) soil moisture will aid decision makers
- SMAP will offer a blended active/passive product with a resolution of around 9 km that will provide an optimal balance between resolution and accuracy



| Name        | SMOS<br>Soil Moisture and Ocean Salinity |                                                                                    | SMAP<br>Soil Moisture Active/Passive |                                                                                     |
|-------------|------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------|-------------------------------------------------------------------------------------|
| Agency      | ESA                                      |  | NASA                                 |  |
| Launch      | 2009                                     |                                                                                    | Nov. 2014                            |                                                                                     |
| Orbit       | Polar                                    |                                                                                    | Polar                                |                                                                                     |
| Sensor Type | Passive                                  |                                                                                    | Active                               | Passive                                                                             |
| Frequency   | 1.4 GHz (L-band)                         |                                                                                    | 1.2 GHz                              | 1.41 GHz                                                                            |
| Resolution  | 35-50 km                                 |                                                                                    | $\geq 1-3$ km                        | 36 km                                                                               |
| Accuracy    | 4 cm <sup>3</sup> /cm <sup>3</sup>       |                                                                                    | 6 cm <sup>3</sup> /cm <sup>3</sup>   | 4 cm <sup>3</sup> /cm <sup>3</sup>                                                  |

# Operational SPoRT LIS

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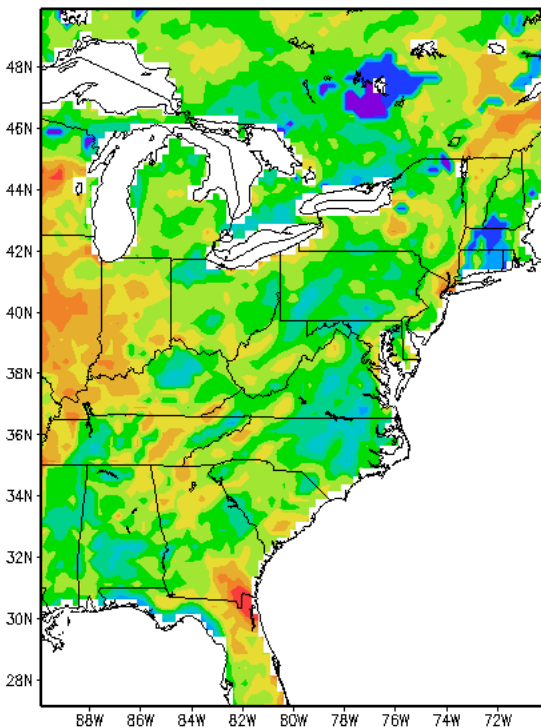
- **NASA Land Information System (LIS) used to perform long-term integration of Noah Land Surface Model (LSM) updated in real-time**
  - Precipitation forcing from NLDAS-2, Multi-Sensor, Multi-Radar (MRMS), and GFS forecast
  - Green Vegetation Fraction data from MODIS (and VIIRS by next year) used for vegetation health
  - Forecast data allows LIS to use latent data observations while retaining their impact in later cycles
- **Assimilation of soil moisture during 2<sup>nd</sup> LIS restart should give even more accurate soil moisture fields in the LSM**
- **Used for situational awareness and local modeling**



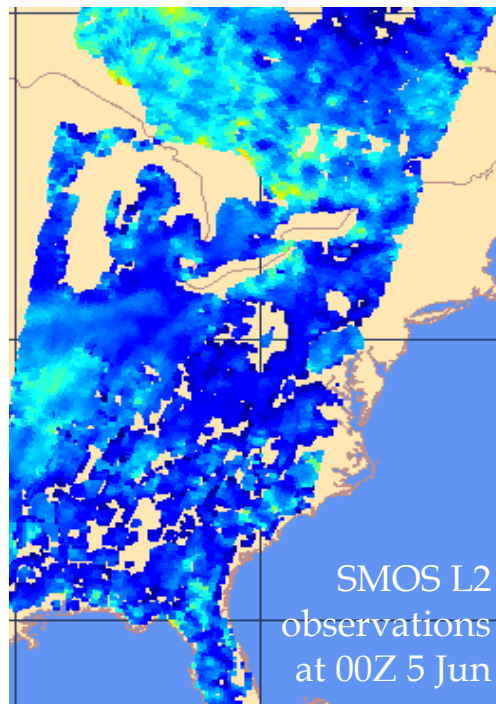
# Soil Moisture Data Assimilation

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SoilMoist 0Z 5 Jun

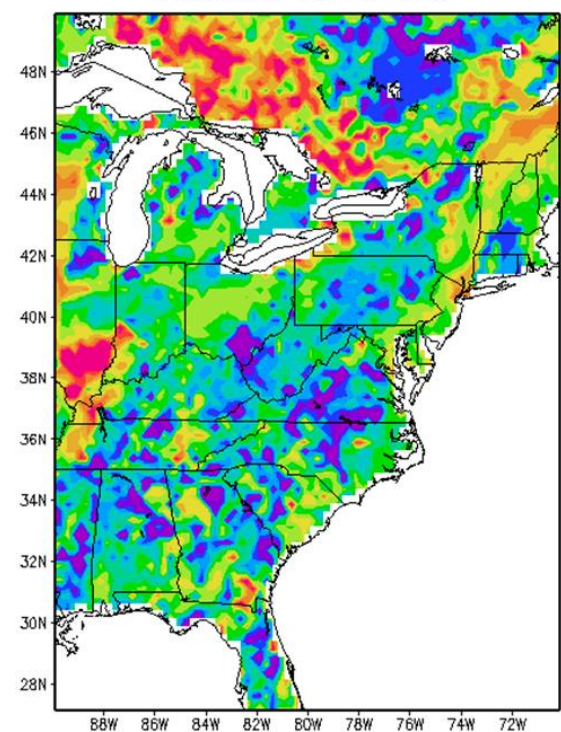


cm³/cm³



SMOS L2  
observations  
at 00Z 5 Jun

SoilMoist 3Z 5 Jun



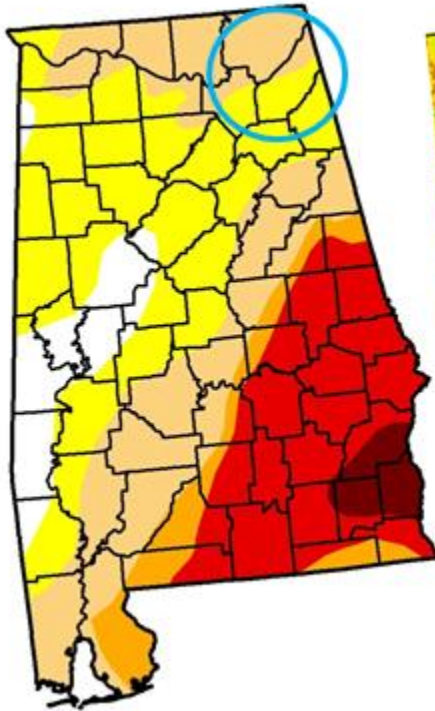
cm³/cm³

- Working to assimilate Level-2 soil moisture observations from SMOS into LIS using internal Ensemble Kalman Filter
  - Data are quality controlled for coastline, rain, vegetation, RFI, and snow cover
  - By assimilating the data, pattern of SMOS observations appears in an analysis with maximums and minimums aligned; currently tuning so analysis doesn't look so much like the observations
- Sample SMAP L2 data available to Early Adopters will be tested with this module

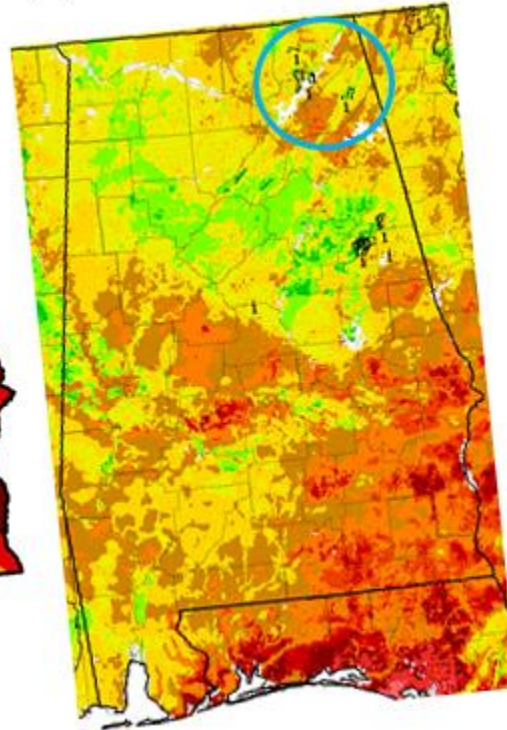
# Applications: Drought Monitoring

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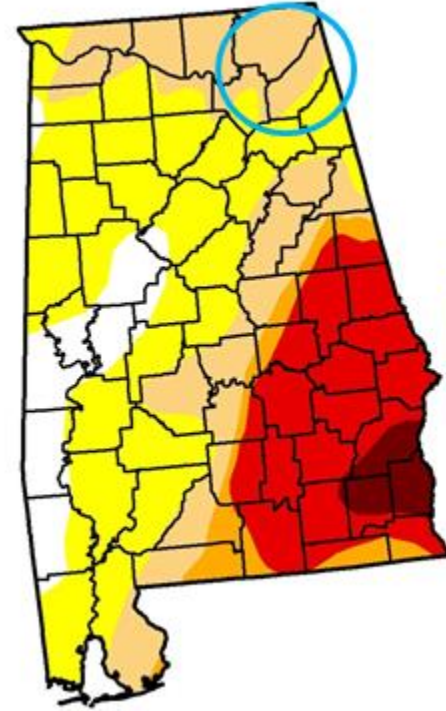
(a) USDM: 1 May 2012



(b) SPoRT-LIS: 8 May 2012



(c) USDM: 8 May 2012



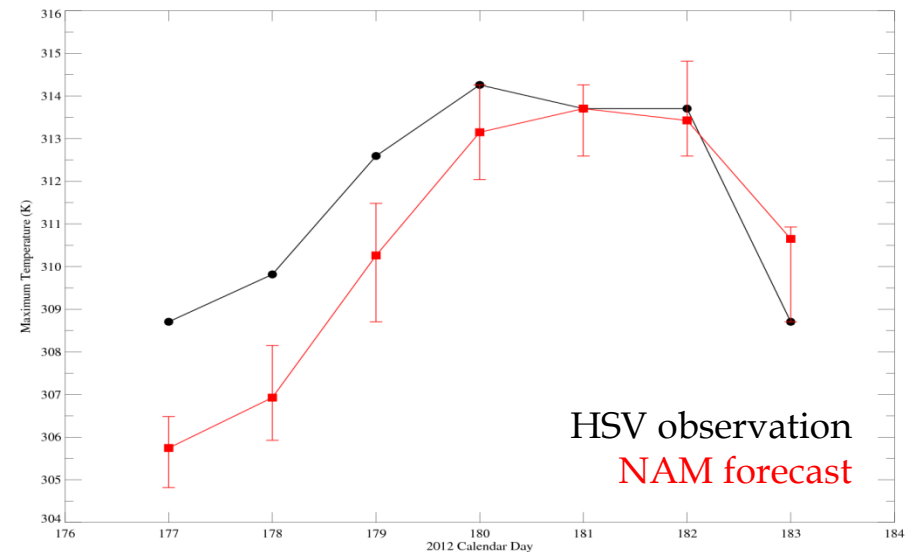
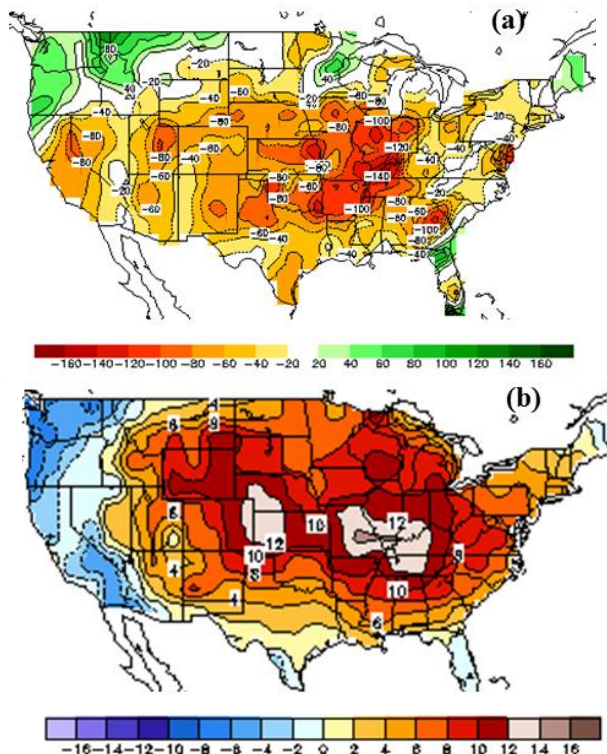
Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

- Soil moisture from SPoRT LIS has been used by NWS forecasters to refine drought indices on the county scale
- Soil moisture and GVF output from LIS could also be applied to situational awareness and forecasts of red flag warnings and potential for fires

# Applications: Heat Maxima

- Extreme heat causes more deaths annually in the U.S. than severe weather events and small differences in T and RH can have large impacts on human health
- NWP models tend to underestimate daytime air temperatures when the modeled soil moisture is higher than the true conditions
- Initializing a local model with LIS fields that have assimilated SMAP data should result in improved max temperature forecasts by providing more accurate soil moisture



Temperature and soil  
moisture anomalies (L)  
and forecast result (R)  
from 26 June to 2 July 2012

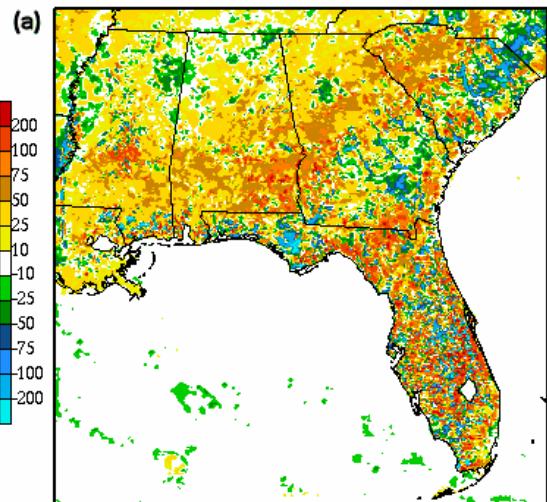




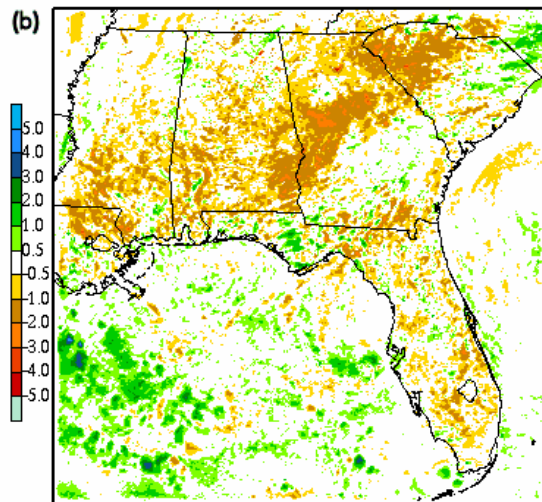
# Applications: Convective Initiation

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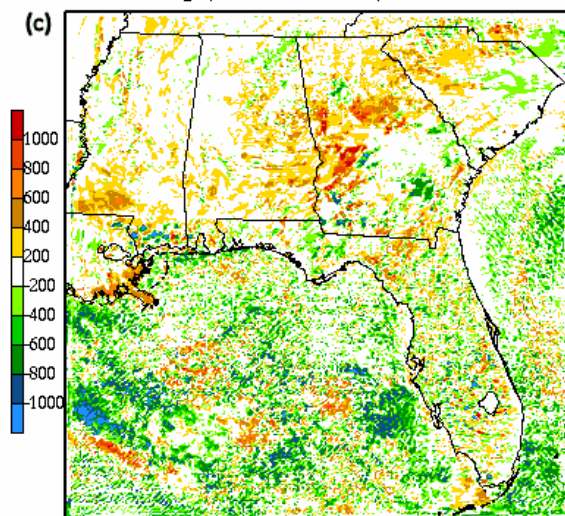
Sensible HF Diff (LISMOD - CNTL) valid 080609/1600V013



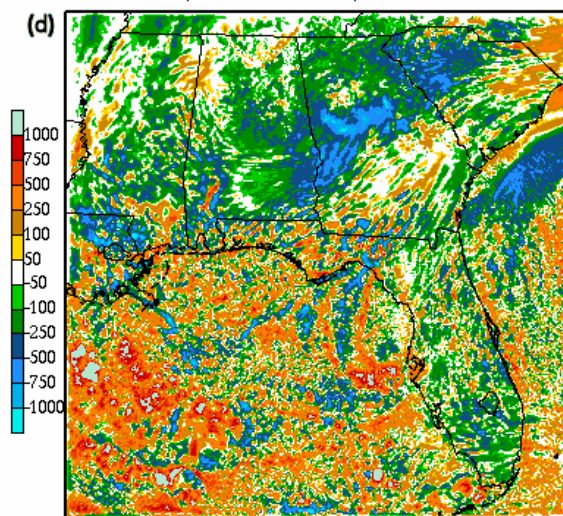
2-m Dewp Diff (LISMOD - CNTL) valid 080609/1600V013



Diff in PBL Hgt (LISMOD - CNTL) valid 080609/1600V013



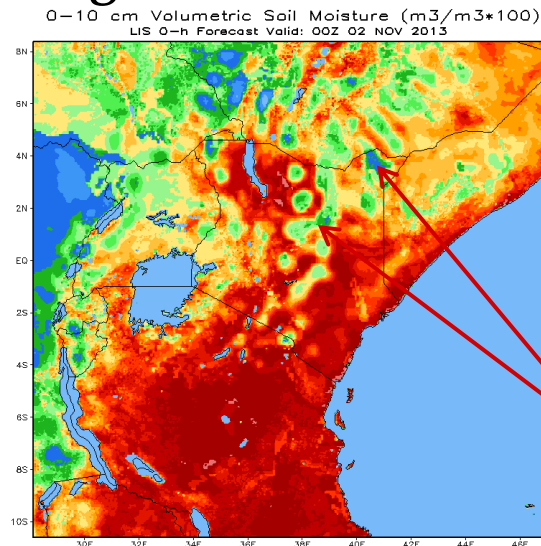
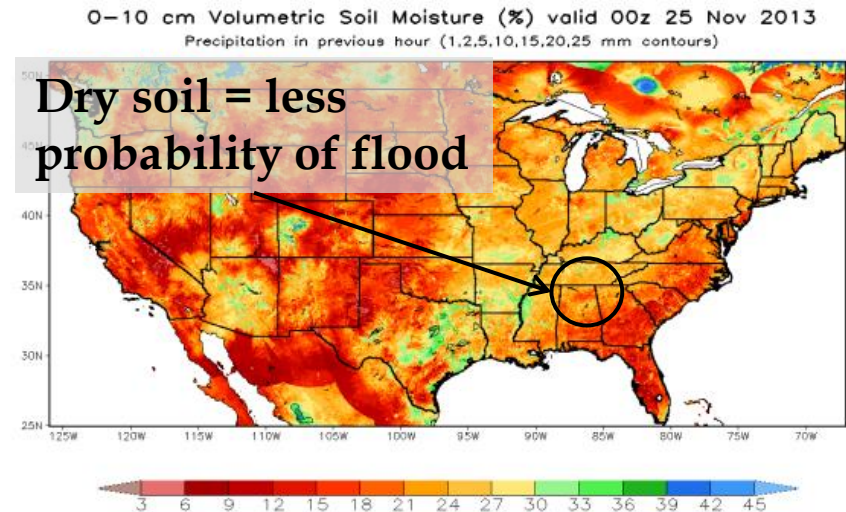
CAPE Diff (LISMOD - CNTL) valid 080609/1600V013



- Soil moisture and GVF gradients have proved sufficient boundaries to initiate convection in weakly-forced regimes
- Use of higher-resolution fields from LIS result in more accurate fields used to predict convection (see figure to left)
- Convective summer storms can generate heavy rain (flash flooding), strong winds, and lightning (fires)

# Applications: Flood and Water Borne Disease<sup>10</sup>

- SPoRT LIS data used by NWS forecasters to issue flood guidance
- Flooded areas and areas with high soil moisture can be breeding grounds for mosquitoes which may carry a number of infectious diseases
- High-resolution, real-time soil moisture fields from LIS could be used to identify areas at highest risk for flooding or water borne disease
- LIS is also being run over Mesoamerica and East Africa where disease prevention may help on a broader scale



CULLMAN/MARSHALL/DEKALB COUNTIES WILL BE MOST LIKELY TO SEE THESE 3+ INCH TOTALS. WITH 3 AND 6 HR FLASH FLOOD GUIDANCE OVER 2 INCHES ACROSS THE CWA...AND DRY SOILS INDICATED IN THE NASA LIS DATA...THIS SUGGESTS WE WILL BE ABLE TO HANDLE MUCH OF THIS RAINFALL SINCE IT WILL BE OCCURRING OVER THE ENTIRE DAY. THAT BEING SAID...WATERWAYS WILL LIKELY SEE SOME GOOD RISES AND ISOLATED FLOODING PROBLEMS MAY DEVELOP. LOCATIONS THAT SEE ANY BURSTS OF HEAVY RAINFALL WILL HAVE TO BE MONITORED CLOSELY...ESPECIALLY SINCE FALL LEAVES ON THE GROUND COULD IMPACT DRAINAGE.

Areas possibly at higher risk for water borne illnesses

# Summary

- **SPoRT produces real-time LIS soil moisture products for situational awareness and local numerical weather prediction over CONUS, Mesoamerica, and East Africa**
- **Currently interact/collaborate with operational partners on evaluation of soil moisture products**
  - Drought/fire
  - Extreme heat
  - Convective initiation
  - Flood and water borne diseases
- **Initial efforts to assimilate L2 soil moisture observations from SMOS (as a precursor for SMAP) have been successful**
- **Active/passive blended product from SMAP will be assimilated similarly and higher spatial resolution should improve on local-scale processes**



# Acknowledgments

- Work is supported by Tsengdar Lee of the NASA Science Mission Directorate through SPoRT
- Would like to thank Susan Moran, Vanessa Escobar, and Molly Brown for including us as SMAP Early Adopters and inviting us to present at this workshop
- Details on SPoRT's real-time LIS and expected use of SMAP data can be found in
  - Zavodsky, B. T., J. L. Case, C. B. Blankenship, W. L. Crosson, K. D. White, 2013: Application of next-generation satellite data to a high-resolution, real-time land surface model, Earthzine, J. Kart, editor, Institute of Electrical and Electronics Engineers [Available online at <http://www.earthzine.org/2013/04/10/application-of-next-generation-satellite-data-to-a-high-resolution-real-time-land-surface-model/>.]

and at the upcoming AMS Annual Meeting:

- Blankenship et al. (28<sup>th</sup> Conference on Hydrology; P53; Tues. Feb. 4)
- Case (26<sup>th</sup> Conference on WAF/NWP; P162; Tues. Feb. 4)
- Case et al. (26<sup>th</sup> Conference on WAF/NWP; J9.4; Wed. Feb 5 @ 2:15 P.M.)

[Brad.Zavodsky@nasa.gov](mailto:Brad.Zavodsky@nasa.gov)

256-961-7914

